

regard as the invention. No new matter has been added by way of the above-amendment.

Issues Under 35 USC 112, first paragraph

Claims 9-10 and 20-21 stand rejected under 35 USC 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventors, at the time the application was filed, has possession of the claimed invention. Applicants respectfully traverse the rejection.

Specifically, the Examiner has objected to claims 9-10 for containing the phrase "a powder Raney catalyst for a fixed bed", and states that Applicants have not shown that they are in possession of a Raney catalyst crushed into a powder and reactivated for a fixed bed.

On this point, Applicants direct the Examiner's attention to the paragraph bridging pages 6-7 of the specification, wherein Applicants state "Additionally, used lump form Raney catalyst may be collected, crushed into powder and then reactivated to be reused." (Emphasis added). The Examiner will note that the preceding two paragraphs characterize the "use" of the catalyst in the fixed bed form. Thus, one skilled in the art would come to the reasonable conclusion, that the term "reused" in the paragraph

bridging pages 6-7 implies that the crushed powder is possibly used in the fixed bed. Therefore, Applicants respectfully request the rejection be withdrawn.

Issues under 35 U.S.C. § 112, second paragraph

Claims 1 and 5-10 stand rejected under 35 U.S.C. § 112 second paragraph as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Applicants respectfully traverse the rejection.

In paragraph four of page 2 of the Office Action, the Examiner states,

In claim 1, when step (iii) is positively required, it is unclear if "said quenched lump alloy" in step (iv) is referred back to the quench lump alloy in step (ii) or the alloy obtained after the breaking step. It should be noted that if step (iii) is required, the lump alloy would be broken into particles and no quench lump alloy remains for step (iv).

In response, Applicants have addressed the Examiner's concerns in the presently amended claim 1.

In the first paragraph of page 3 of the Office Action, the Examiner objects to claim 5 for containing the phrase "activating said quenched lump alloy or said quenched alloy particles to form a Raney catalyst", and alleges that this phrase renders the claims unclear since there would be no quenched lump alloy if the breaking and classifying steps are positively required. In response,

Applicants have clarified claim 5 by replacing the phrase "activating said quenched lump alloy or said quenched alloy particles to form a Raney catalyst" with the phrase "activating said quenched alloy particles to form a Raney catalyst".

The Examiner finds that the phrase "the lump Raney catalyst" as found in claims 6-8 and 20-21 do not have antecedent basis in the claims from which they depend. In response, Applicants have amended claims 6, 8 and 20 by deleting the term "lump". In view of the above-amendments and comments, Applicants respectfully submit that the presently amended claims particularly point out and distinctly claim the subject matter which applicant regards as the invention. Withdrawal of the rejection is respectfully requested.

Issues under 37 C.F.R. 1.75(c)

Claims 7-8 are objected to under 37 C.F.R. 1.75(c) as being of improper dependent for failing to further limit the subject matter of the previous claim. Applicants respectfully traverse the objection.

It appears that the Examiner has made an error in the last two sentences of paragraph 3 of page 3, by referring to claims 5 and 1. It appears that the Examiner meant to write the following.

"In the independent claim 5, it is requires that the fixed bed catalyst 'consisting of a nickel aluminum alloy

with molybdenum and /or tin up to 15%', however, in claim [7], it is required that the mixture which is used to make the catalyst 'consisting essentially of aluminum and nickel'. The 'consisting essentially of' in claim [7] fails to further limit the 'consisting of' language in claim [5]."

In response, Applicants have canceled claim 7 and amended claim 8 to depend from claim 5. As such, Applicants respectfully request that the objection be withdrawn.

Interview

Applicants note with appreciation that the Examiner has taken the time to conduct an Interview with Applicants' representative, Garth M. Dahlen, Ph.D. (Registry No. 43,575) on October 31, 2000.

On the Interview Summary Form, the Examiner states:

"Discussed the rejections. Both the preferred embodiment and the prior art sections of Schuetz '694 are relied upon for the rejections. Declaration to show that there is a difference between the claimed product and the product of the applied prior art would be helpful."

A more detailed description of the Interview is as follows.

Issues Under 35 USC 102 and 103

The following rejections are pending:

(1) Claims 5 and 7 stand rejected under 35 U.S.C. §102(e) as being anticipated by or, in the alternative under 35 U.S.C. §103(a) as obvious over **Schuetz et al.** (US 5,536,694);

(2) Claims 5, 7, 8 and 19 stand rejected under 35 U.S.C. §103(a) as being unpatentable over **Schuetz et al.**;

(3) Claims 6 stands rejected under 35 U.S.C. §103(a) as being unpatentable over **Schuetz et al.** and further in view of **Lepper et al.** (US 4,520,211);

(4) Claims 1, 5, 7-10 and 18-21 stand rejected under 35 U.S.C. §103(a) as being unpatentable over **Schuetz et al.** in view of **Raney** (US 1,628,190) and optionally further in view of **Richter** (US 3,673,116);

(5) Claim 6 stands rejected under 35 U.S.C. §103(a) as being unpatentable over **Schuetz et al.** in view of **Raney** optionally in view of **Richter** and further in view of **Lepper et al.**;

(6) Claims 5-8 stand rejected under 35 U.S.C. §103(a) as being unpatentable over **Diffenbach et al.** (US 3,719,732) in view of **Lepper et al.**; and

(7) Claims 1, 5-10 and 18-21 stand rejected under 35 U.S.C. §103(a) as being unpatentable over **Diffenbach et al.** in view of **Lepper et al.** and further in view of **Schuetz et al.**

Applicants respectfully traverse the rejections (1)-(7).

Rejections (1)-(5)

In each of the rejections (1)-(5), **Schuetz et al.** is the primary reference. It is the Examiner's position that if Applicants are able to distinguish the presently claimed catalyst from the teachings of **Schuetz et al.**, that the Examiner would withdraw rejections (1)-(5). More specifically, the Examiner notes that claims 1, 5-10 and 18-21 are in the product-by-process format, and as such, the process limitations will be given more patentable

weight after the process limitations are shown to actually form a product which is distinct from the product produced by the prior art. With this in mind, Applicants will now attempt to explain how the Examiner is viewing the disclosure of Schuetz et al.

The Examiner is separating the disclosure of Schuetz et al into two separate parts:

- (A) the DETAILED DESCRIPTION OF THE INVENTION section; and
- (B) the background section at lines 42-63 of column 1.

Parts (A) and (B) are now addressed *seriatim*.

(A) *The DETAILED DESCRIPTION OF THE INVENTION Section -*

Regarding part (A), the Examiner responded favorably during the Interview to the following arguments and appeared to find that these arguments adequately distinguished the present invention from part (A) (the DETAILED DESCRIPTION OF THE INVENTION section of Schuetz et al.).

The conventional Raney catalyst, which has lost its activity through use as a hydrogenation catalyst, is discarded. The present Inventors have discovered that the inactive lump form catalyst can be reused/reactivated either in the lump form or in the powder

form, when the lump form has been produced by a certain method. In other words, the present invention relates to recyclable lump form Raney catalyst and to powder type Raney catalyst obtained by reactivating used lump form Raney catalyst.

The present invention is characterized in that the powder type Raney catalyst is consistently obtained as a highly active powder type Raney catalyst by reusing used lump form Raney catalyst no matter how many hydrogenation cycles it has been exposed to. In other words, used lump form Raney catalyst can be reused as raw material for powder type Raney catalyst whether the catalytic activity of the used lump form catalyst remains or not. Moreover, the thus obtained powder type Raney catalyst is available with as high catalytic activity as the conventional Raney catalyst has, even though the powder type catalyst has been obtained from the used catalyst.

The characteristics of the present invention will now be explained herein-below, referring to a cross-sectional view of an activated lump form Raney catalyst of the present invention. The catalyst particle has been enlarged by a scanning electron microscope (PHOTO 1, see the attached).

This photograph is evidence that the activated lump form Raney catalyst is present has different layers. The outer layer which appears bright in the photograph represents an activated catalyst

whereas the inner layer which appears relatively dark represents the inactive form of the catalyst. Thus there is a large amount of lumped inactivated catalytic alloy (nickel-aluminum alloy) inside the activated catalytic layer. The inactive layer is possible, since the alkali solvent, such as an aqueous sodium hydroxide solution, is prevented from penetrating into the core of the particle by the active surface layer.

The lump form Raney catalyst which has an evenly thick active surface layer of the catalytic alloy will lose its activity upon repeated use as a hydrogenation catalyst. However, the catalytic alloy existing inside of the used lump form Raney catalyst can be activated by crushing the lump catalyst, thereby exposing the inactive inner layer followed by activation treatment with an alkali solution.

(i) Difference in ingredients between the inventive catalyst and the catalyst disclosed by Schuetz et al.

The Examiner has indicated that he finds no difference between a binder, made of the Raney process metal, used in the process of Schuetz et al. and powder type Raney catalyst according to the present invention. However, lump form Raney catalyst of the present invention involves the integration of quickly quenched molten nickel-aluminium, while the catalyst disclosed in Schuetz et al.

is obtained by sintering powder type catalytic alloy with binder ingredients. In other words, there is a difference resulting from the fact that lump form Raney catalyst of the present invention involves metallic lumps, while the catalyst disclosed in the cited reference is agglomerated powder keeping the shape of catalyst with the help of binder binding the powder type catalyst.

Now, this difference will be explained more concretely. Schuetz et al. state, at column 5, lines 13 to 20:

"These properties are closely connected with the pure Raney process metal used as binder which is not dissolved out during leaching and thus in the sintered product forms stable bonds between the individual alloyed particles. In contrast, sintering the catalyst alloy powder without adding the metal binder leads to molded items which partially disintegrate or 'decompose' during leaching and in which the activated layer has only a low resistance to abrasion."

Usually, Raney catalyst is obtained by extracting dissolved aluminum ingredients in alkali treatment of an alloy made from combination such as nickel-aluminium. However, the above description is evidence that the binder used in production of catalyst disclosed by Schuetz et al. is added for the purpose of making a molded catalyst keeping the bond of powder type catalytic alloy and does not contain the metallic ingredients dissolved out by alkali treatment such as aluminum, zinc, silicon. A binder such

as used in Schuetz et al. patent does not contain the ingredients were dissolved and removed during activation, and therefore, does not work as a hydrogenating agent in binding portions.

In other words, the catalyst disclosed by Schuetz et al., is formed with a binder having no catalytic activity and the catalyst would contain this inactive metallic powder even after a crushing step.

In contrast, lump form Raney catalyst of the present invention wholly consists of nickel-aluminum alloy. The recyclable catalytic alloy can be collected upon crushing the lump form Raney catalyst, even after it has been rendered inactive through continued use as a hydrogenation catalyst. In other words, aluminum ingredients evenly contained in the powder formed by crushing the used lump form Raney catalyst can be removed by subjecting the powder to alkali treatment, thereby obtaining highly active powder type Raney catalyst with minimal capital costs.

To compare the two, the catalyst of Schuetz et al contains ingredients which cannot be rendered catalytically active is obviously different in composition from the lump form Raney catalyst of the present invention containing no binder at all and consisting only of catalytic alloy (nickel-aluminum alloy).

Incidentally, the Examiner points out in Office Action that Schuetz et al. patent refers to the availability of both lump form

catalyst and powder type catalyst. However, Schuetz et al. disclose only the conventional powder type catalyst and fail to teach or suggest either powder type Raney catalyst obtained by crushing a molded catalyst or reusing the molded catalyst once rendered inactive upon continued use as a hydrogenation catalyst. The physical distinctions between the powder form of the catalyst of Schuetz et al and the inventive powder form is addressed, *infra*.

(ii) -Difference in structure from catalyst disclosed by Schuetz et al.

Now, Applicants address the obvious difference of lump form Raney catalyst of the present invention from catalyst disclosed by Schuetz et al.

The catalyst disclosed in Schuetz et al. patent involves a sintered mixture of the powdered catalyst alloy and binder. This catalyst is characterized by Schuetz et al., as follows (see column 4, lines 51 to 65):

"The final molded items are optionally dried to constant weight at temperatures between 80° and 120°C. and then calcined at temperatures below 850°C. preferably between 500° and 700°C, in air in continuous or batch operated kilns such as rotary kilns or stationary kilns. The organic additives then burn off and leave behind a corresponding pore system.

The pore structure and pore volume of the catalysts can be varied over a wide range by suitable selection of

the pore producing additives. The final pore structure which is developed and the pore volume are also affected by the particle sizes of the powders of catalyst alloy and binder employed. The structure of the molded item can be adapted to the requirements for the particular catalytic process by appropriate selection of the parameters mentioned."

Moreover, the Schuetz et al states, at column 6, lines 45 to 47:

"Due to the preparation method the pore volume of the activated catalysts consists mainly of macropores which normally are measured by mercury intrusion."

The above description proves that the catalyst disclosed by Schuetz et al. has a porous structure all over the catalyst in view of the adjusting method. In addition, the molded catalyst disclosed by Schuetz et al. removes the aluminum ingredients from its inside by activation with alkali solvent, thereby further increasing the pore volume, finally making a catalyst having the above macropores.

On the other hand, lump form Raney catalyst of the present invention has a homogeneous metallic form which has been quickly quenched into the lumped form catalytic alloy having no porous structure prior to activation. Then, during the activation step, lump form Raney catalyst of the present invention is activated only on the catalytic surface layer to make a porous structure only on

the catalytic surface layer, without making the inside porous and keeping it in the same condition as before activation.

The lump form Raney catalyst is characterized in the specification of the present application on page 2, lines 33 to 35, as follows:

"It is important to increase the density of catalyst to be loaded and to regulate the solution flow in the fixed bed for efficient hydrogenation during the sugar-alcohol production."

Based on the above observation, lump form Raney catalyst of the present invention produces intrinsically metallic lumped high-density catalyst. On the other hand, the catalyst in the cited reference is obviously different in density of catalyst, since it has a macroporous structure throughout.

As explained above, the catalyst disclosed by Schuetz et al. is quite different from recyclable lump form Raney catalyst of the present invention, since it is a molded catalyst involving the agglomeration of a powder type catalyst alloy sintered with a binder, containing binder ingredients having no catalytic activity, having a porous structure already before activation, different in catalytic density, etc. The powder type catalyst that Schuetz et al briefly allude to would not have sufficient catalytic activity,

since it contains binder ingredients which are catalytically inactive.

In addition, Schuetz et al neither refers to nor suggests reusing crushed lump form Raney catalyst newly formed as a powder type Raney catalyst. Therefore, there are significant patentable distinctions between the present invention and the teachings of derived from any combination of the cited references.

(B) the Background section at lines 42-63 of column 1 of Schuetz et al. -

The following remarks are provided to convince the Examiner that the process limitations should be given more patentable weight since the process limitations of the present claims actually form a product which is distinct from the product produced by the prior art.

Schuetz et al states in the Background section of the patent that coarsely milled Raney alloy is activated only on outer layers of catalytic surface by activation with caustic soda solution and the activated layers can be prepared by leaching conditions. Moreover, Schuetz et al state from line 64 of column 1 to line 3 of column 2 that they can be "partially reversed" by activation using caustic soda solution after having been rendered activity.

As seen from the above, Schuetz et al. disclose the presence of inner catalytic layers susceptible to activation after the coarsely milled Raney alloy has been rendered inactive. However, the catalyst of the present invention is characterized in that the inactive used lump form catalyst is crushed into powder and is wholly reused. In short, the catalyst by Schuetz et al is only partially reactivated whereas the crushed powder of the present invention is wholly reactivated.

This difference in characteristics has resulted from the crushing step of the present invention to make powder type catalyst for the purpose of reusing the catalyst.

Thus, there are significant patentable distinctions between the present invention and the teachings of derived from any combination of the cited references. As such, Applicants respectfully request that rejections (1)-(5) are withdrawn.

Rejections (6)-(7)

Diffenbach et al. is the base reference in each of rejections (6)-(7).

During the Interview, the Examiner took the position that the melt and quenching step of Diffenbach et al. is not patentably distinct from the inventive melt and quenching step. Furthermore,

the Examiner requested that Applicants provide a distinguishing feature between how the melt and quenching step of the inventive operative embodiments differ from that of the operative embodiments of Diffenbach et al. The following discussion addresses the Examiner's concerns.

(i) With regard to the melting and quenching steps -

The inventive catalyst is different in shape from that of Diffenbach et al., possibly due to the temperature of molten alloy which is subjected to the quenching step i.e. the melting point of the molten alloy.

An Al-Ni phase diagram (Teruo KUBOMATSU, Shinichiro KOMATSU, Raney catalyst, page 27, May 10, 1971) is attached hereto for reference. The diagram shows that the melting point of a melted aluminum-nickel mixture and the composition of an alloy obtained in quenching the molten metal of the composition.

The Al-Ni phase diagram is commonly used to show the melting point of an Al-Ni alloy and the composition of the alloy obtained upon cooling. Its vertical axis represents the temperature, while the lower horizontal axis represents an atomic (mole) ratio of Ni and Al in the mixture and the upper horizontal axis indicates a weight ratio of Ni and Al in the mixture. The uppermost curve shows

the temperature where the mixture of the composition ratio is completely molten i.e. the melting point of the alloyed substance. The portion under the curve or at lower temperatures represents the solid portion, showing the metallic composition of solidified Al-Ni alloys. For example, an alloy having a composition of NiAl is dominant in cooling at room temperature a molten metal having the range of 45 to 59 ATOMIC PER CENT NICKEL. On the other hand, an alloy of composition of Ni_2Al_3 dominates in the range of 36 to 41 ATOMIC PER CENT NICKEL. Two types of alloys of compositions Ni_2Al_3 and NiAl coexist in the range of 41 to 45 ATOMIC PER CENT NICKEL at the interval between the above.

The difference between the present invention and the catalyst disclosed by Diffenbach will be explained here below, referring to the phase diagram.

The catalyst disclosed by Diffenbach has a high aluminum content. All catalytic alloys produced in Diffenbach's Examples have an aluminum content of 70 weight % or more. When the aluminum content is 70 weight % (i.e. nickel content of 30 weight %), the melting point is about 900°C according to the attached Al-Ni phase diagram. Therefore, the melting point of catalytic alloy produced in Diffenbach's Examples does not exceed 900°C at a maximum.

When an alloy molten in the above temperature range is dripped into water, something like a water vapor film is thought

to be formed by evaporation of water on the surface of the molten metal. However, the water vapor film formed at this temperature has such a poor strength that the ambient cooling water breaks the water vapor film, likely to have a direct contact with the molten metal. Then, the cooling water is thought to come into direct contact with the catalyst, resulting in minute water vapor explosion to form a catalyst shaped as described by Diffenbach in the specification.

On the other hand, the aluminum content is lower in the present invention than disclosed by Diffenbach (usually 66.6 to 33.3 weight % or preferably 50 weight %), having a nickel content of 33.3 to 66.6 weight % or preferably 50 weight %. The melting point of the alloy then is about 950°C at a nickel content of 33.3 weight %, about 1300°C at a nickel content of 50 weight %, and about 1600°C at a nickel content of 66.6 weight % according to the Al-Ni state diagram. In other words, the melting point of the catalytic alloy of the present invention is at least 950°C and more preferably as high as 1300°C. This is much higher than the catalyst of Diffenbach.

When molten catalytic alloy having such a high melting point is dripped into water, water evaporates on the surface of molten alloy as in the case of Diffenbach. However, water vapor is thought to be instantaneously generated by the high temperature of the

molten alloy, thereby forming a stronger water vapor film on the catalytic surface. Then, this high strength water vapor film formed there is thought to prevent water vapor explosion on the catalytic surface due to direct contact between the catalytic alloy and the cooling water. As a result, the catalytic alloy of the present invention is thought to be solidified in lump as dripped, instead of being formed as described by Diffenbach.

As explained above, the catalysts of Diffenbach are obviously different in melting temperature from the catalysts of the present invention, and this difference in temperature is thought to influence the shapes of catalysts obtained by quenching the molten alloy. Thus, the Examiner must conclude that there exists at least one distinguishing feature between how the melt and quenching step of the inventive operative embodiments differ from that of the operative embodiments of Diffenbach et al.

The following explanation is provided to further distinguish the present invention from the teachings of Diffenbach et al.

Diffenbach et al. describes their own invention in column 2, lines 40 to 51, as follows:

"Broadly, this invention comprises methods of forming aluminum-nickel, aluminum-cobalt, aluminum-copper and aluminum-iron alloys, or mixtures, into shaped particles

of comparatively high surface area. This property of high surface area is of concern, since the preferred end use for these shaped particles is in the formation of highly active metal catalysts of the Raney type. As used in this application, a Raney nickel, cobalt, copper or iron has been put in a high surface area, highly active condition via the technique of alkali leaching the aluminum content out of the alloy."

As seen from the description of this specification, Diffenbach et al. teaches that a high surface area of the catalyst is an important factor to obtain a highly active catalyst.

Then, Diffenbach et al. refers to various cooling methods used in production of Raney catalyst to obtain grained molded active catalyst from molten alloy. Diffenbach et al. refers here to use of water as a cooling method for molten alloy, describing the shape of molded molten alloy quenched by the use of water in column 3, lines 27 to 47, as follows:

"The basic technique most useful for alloy shaping is melt forming, that is, putting the alloy into a shape while in a melt condition with subsequent cooling to ambient temperatures. The shapes of preferred importance are those of FIGS. 4 and 5, although essentially any shape can be utilized. The aim of any shape, however, is to attain a high surface area while maintaining crush resistance and still minimizing pressure drop on the fixed bed reactors. The shapes of this invention are produced by dropping molten alloy into or onto a cooled medium. When dropped onto a cold medium such as a plate, the drop will spread to the form of a disc. If a shaped cold surface is used, the drop will form a shape complementary to the cold surface to which it was contacted. When dropped into a cold medium, which can be

water or some surface, the drop deforms to form a novel shape depending on the liquid, the energy of the falling drop, and its melt condition. The preferred particle shape from this technique is an essentially hollow, partially spherical particle. Particles of any of these types have proven to subsequently yield very active Raney catalyst."

The specification of Diffenbach et al. says that "essentially any shape can be utilized." (see column 3, lines 31-32) as the shape of molded catalyst disclosed by Diffenbach et al., while referring to a higher catalytic surface area as a preferred embodiment. Moreover, it discloses "an essentially hollow, partially spherical particle" (see column 3, lines 45-46) by way of concrete example of its preferred particle shape. These descriptions are evidence that the catalyst disclosed by Diffenbach et al. is based on a technical idea quite distinct from that of the present invention. The invention of Diffenbach et al. aims to obtain the catalyst having a high activity by means of increasing the surface area of the catalyst by forming the grained catalyst into a concave shape. While the present invention is characterized by that the lump form catalytic alloy is activated only on the surface layer, keeping inactive catalytic alloy inside the catalyst, thereby enabling it to be reused into powder type Raney catalyst even after rendered inactive as the lump form Raney catalyst through repeated hydrogenation.

The concept of reusing a catalyst by the method of the present invention is obviously missing in the catalyst of Diffenbach et al. constructed to have a cavity inside, having no catalytic alloy. On the contrary, the present invention can not be realized by using a catalyst shaped as disclosed by Diffenbach et al., since no catalytic alloy for reactivation remains inside lump form Raney catalyst.

Moreover, the present invention can not be easily derived from any combination with any other cited references, since the specification of Diffenbach et al. makes no reference to nor suggests the recycling of catalyst.

In conclusion, the present catalyst has significant patentable distinctions from the catalyst of Diffenbach et al. As such, Applicants respectfully request that rejections (6)-(7) are withdrawn.

Conclusion

In view of the above comments and amendments, Applicants respectfully submit that the claims are in condition for allowance. A notice to such effect is earnestly solicited.

Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact Garth M. Dahlen (Reg. No. 43,575) at the


telephone number of the undersigned below, to conduct an interview in an effort to expedite prosecution in connection with the present application.


Pursuant to 37 CFR 1.17 and 1.136(a), the Applicants respectfully petitions for a three (3) month extension of time for filing a response in connection with the present application and the required fee of \$445.00 is attached hereto.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17; particularly, extension of time fees.

Respectfully submitted,

BIRCH, STEWART, KOLASCH & BIRCH, LLP

By 
Raymond C. Stewart, #21,066

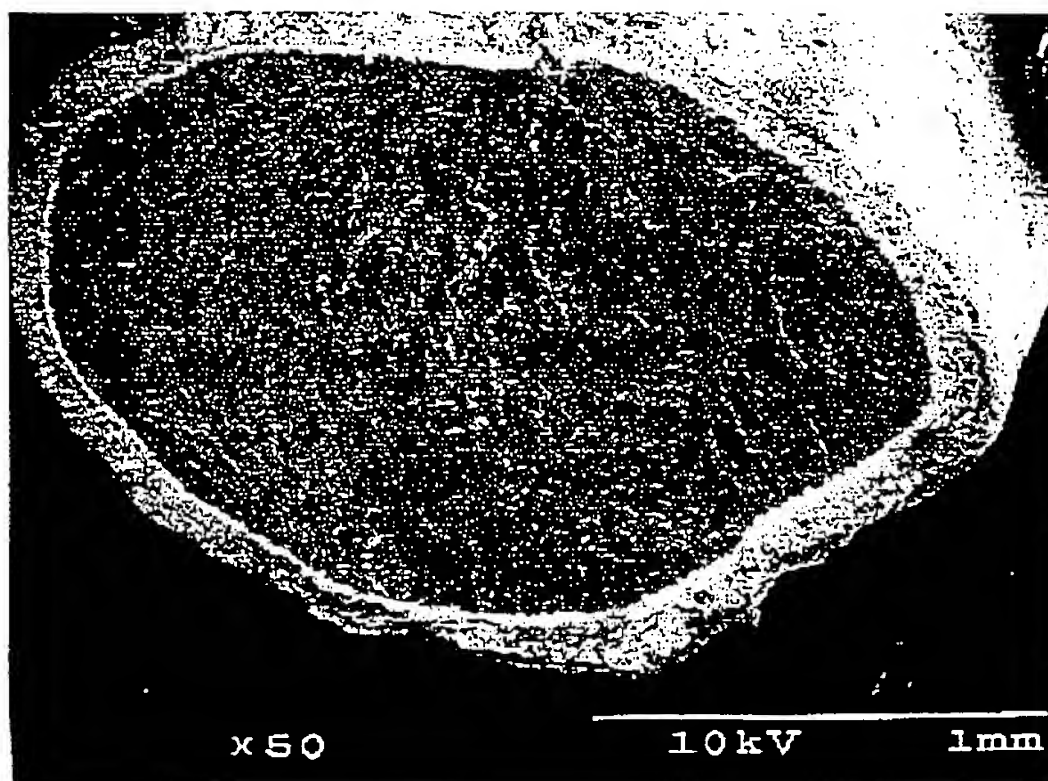

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SEM photography of lump form Raney catalyst of the present invention

Measuring device: HITACHI S-2460N

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27

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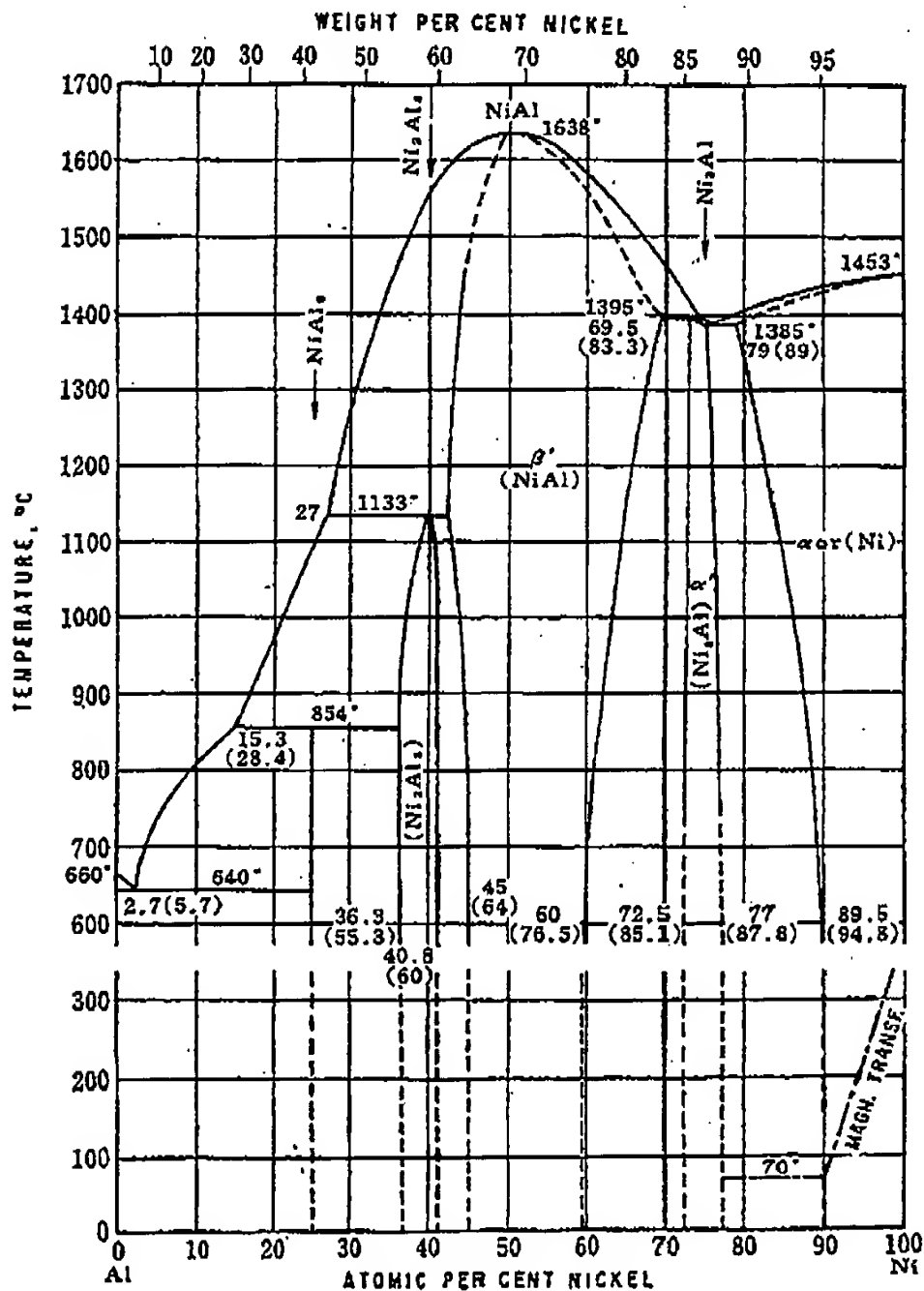


図 2.1 Ni-Al state diagram

by Max Hansen "Constitution of Binary alloys" 2nd Edition.

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